



Open Architecture Machinery Control Systems

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Main Concepts for a New Approach to MCS

- A Business Case for OA MCS
- Zonal Architecture Improves Acquisition and Shipboard Performance
- Naval Open Architecture and Product Lines Applied to MCS
- Next Steps



Open Architecture Defined

Naval Open Architecture:

- ***Business practices***
- ***Technical practices***

Produce Systems:

- ***Based on open standards***
- ***Published interfaces***

Can a qualified third party add, modify, replace, remove, or provide support for a component of a system, based only on openly published and available technical and functional specification of the component of that system

OA CORE PRINCIPLES

Modular, Loose Coupling, High Cohesion

Design Disclosure and Data Rights

Enterprise TOC Reduction and Reuse

Transparency and Peer Reviews

Competition and collaboration

ROI and Strategic Investments

The Business Case for OA MCS - Development

- Cost Avoidance in MCS Development and Ship Construction
 - Cross-Platform Product Reuse
 - Integrated Logistics Support
 - Incremental Testing
 - Improved Schedule Performance
 - Ship Construction Risk Reduction
- Improved Performance
 - Access to Innovation
 - Support for Automation



The Business Case for OA MCS - Life Cycle

- Cost Savings over the Life-Cycle
 - Common Training
 - Common Logistics
 - Distance Support
 - Transparency of Equipment Status Internal and External to the Ship
 - Reduction in Software Maintenance – MFOP

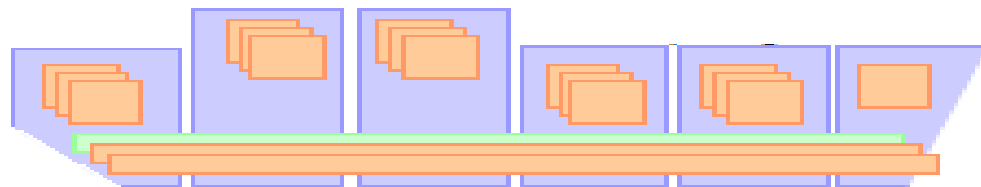
Fiscal Year	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Aircraft Carrier			1					1					1					1					1					1		
Large Surface Combatant	2	1	2	1	2	1	2	1	2	1	2	1	2	1	1	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2
Small Surface Combatant	2	3	4	4	4	3	3	3	3	2	2	2	2	2	1	2	1	2	1	2	1	2	1	2	2	2	2	2	2	2
Attack Submarines	2	2	2	2	2	2	2	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	
Ballistic Missile Submarines									1			1		1	1	1	1	1	1	1	1	1	1							
Amphibious Warfare Ships	1	1				1	1		1		2		1		2		1		2		1		2		1		1	1	1	
Combat Logistics Force							1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	
Support Vessels	2	1	3	2	4	2	3	3	3	4	2	3	3	2	1			1		2	1	1	2	2	2	2	2	2	2	2
Total New Construction Plan	9	8	12	9	12	9	12	9	13	9	11	10	11	8	8	7	7	8	8	8	8	8	11	8	10	7	10	9	10	7

Current State of Practice

OA Enables Competition for development and support

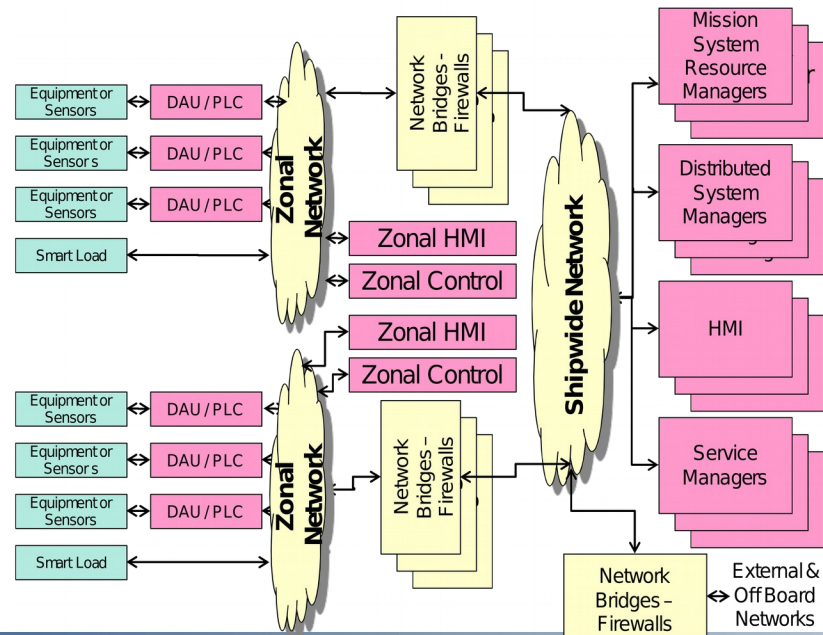
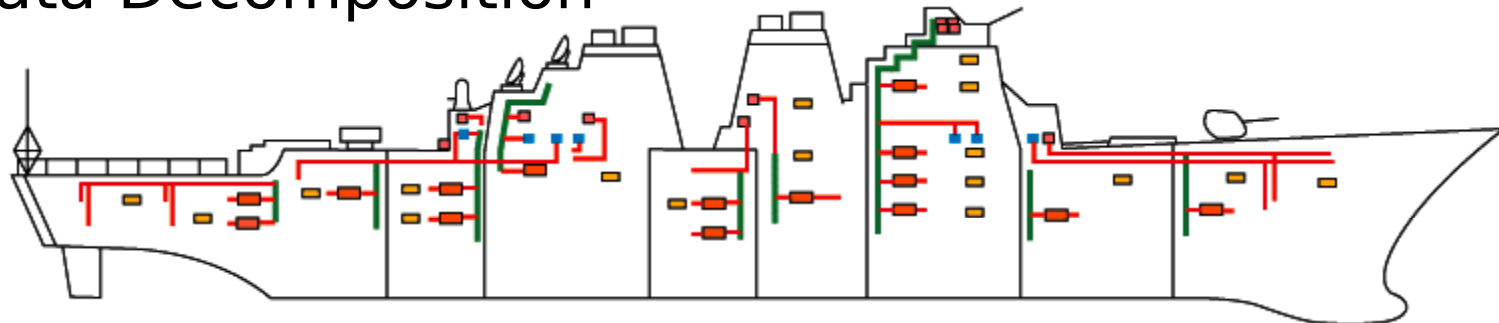
Zonal Architecture - Divide and Conquer

- Benefits of a Zonal Architecture
 - Enhanced Survivability
 - Local Control and Recovery
 - Information Assurance: Defense-in-Depth
 - Decompose Network Design for hierarchy of real-time performance
 - Ship Construction testing and integration risk reduction
 - Increased Maintainability and Troubleshooting
- Smart-loads minimize MCS design complexity



Zonal Architecture Characteristics

- Compartmentalization
- Data Decomposition



Additional Features of OA MCS

- Cross-platform reuse to increase cost performance
- Elimination of proprietary design environments
 - Soft PLCs
 - Common HMI
- Escape hardware and software vendor-lock
- Reduced Enterprise Cost
- Rapid access to innovation
 - Technology Insertion
- Transparency of Design Strategy and Resources
 - Objective Architecture Defines Global Strategy
 - Open Data Model to support integration of new components
 - SDKs and Test Harnesses reduce system integration risk and test effort

OA Applied to MCS

- Classic Approach
 - Independently Designed and Acquired on a Ship Class Basis
 - CFE by the Ship Builder
 - Typically Subcontracted
- OA MCS Approach
 - General MCS Functional Decomposition
 - Define the MCS Objective Architecture
 - Define Supplier Market Boundaries
 - Apply to a specific ship class
 - Evolve the Family of Systems through Product Lines
 - Establish an acquisition framework for incorporating innovation
 - APB/ACB methodologies for software upgrades
 - Technology Insertion strategies for hardware sustainment
 - MCS Reusable Modules as GFE for modification and

Naval Open

Architecture:

- ***Business practices***
- ***Technical practices***

Produce Systems:

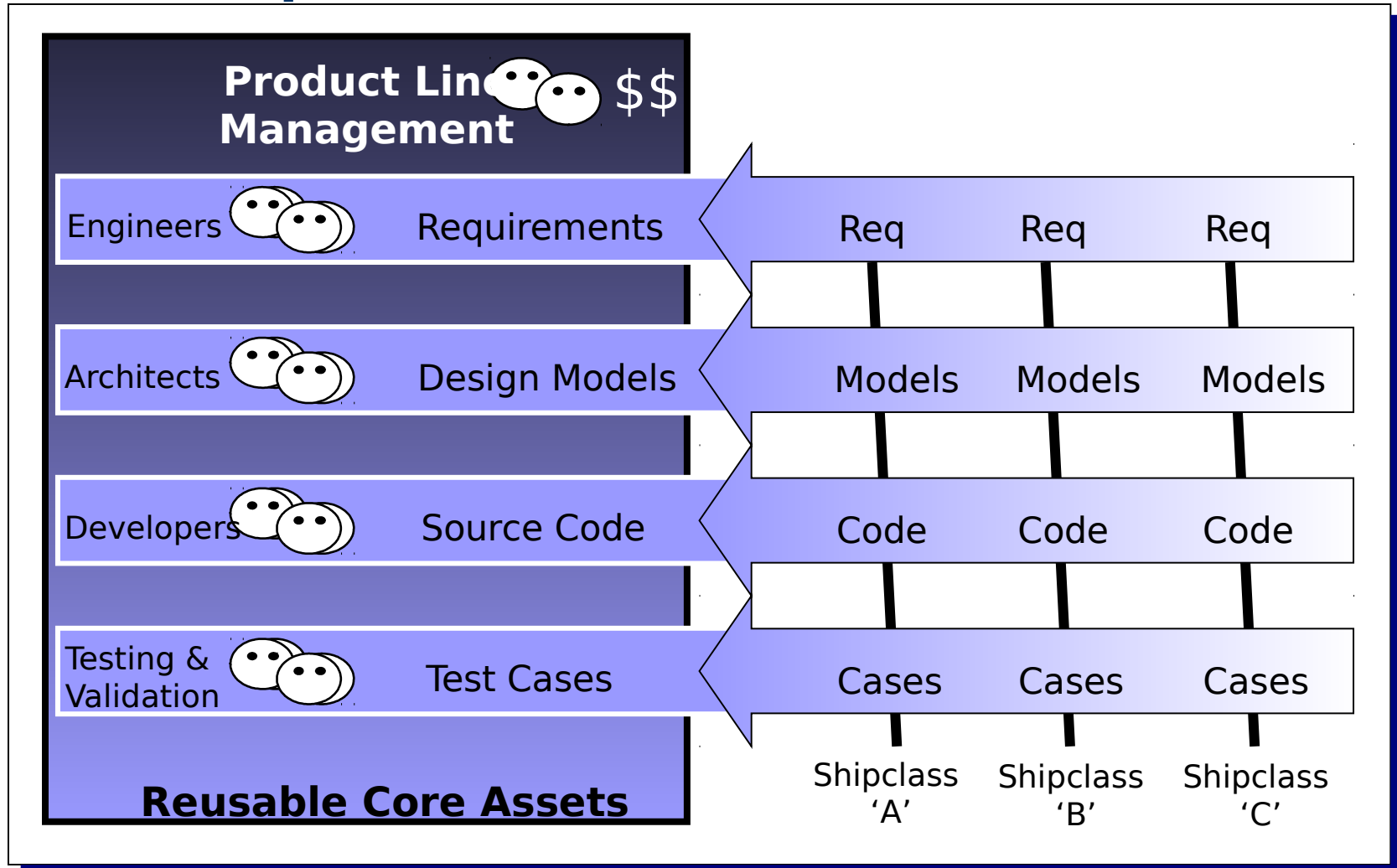
- ***Based on open standards***
- ***Published interfaces***

Open Product Lines - the Next Step in the OA Revolution

- Product Line Focus: Build once, use subsequent variations
 - Lower Cost to Upgrade
 - Higher Quality
 - Cross-platform utility
 - Forward/Backward compatibility
- Reuse
 - Open and managed reused components – strategic reuse
 - Published architecture that specifies how features and behaviors are varied between products
 - Assets can be competed as technology advances and/or mission needs change
 - Reusable test scripts, plans, assets and harnesses shorten process and simplify execution

See: **Delivering Savings with Open Architecture and Product Lines;**
Comble, Arendt, Fain, Schmidt. <https://acc.dau.mil/oa>

Product Lines - Cross-platform use via variation points



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We are not alone

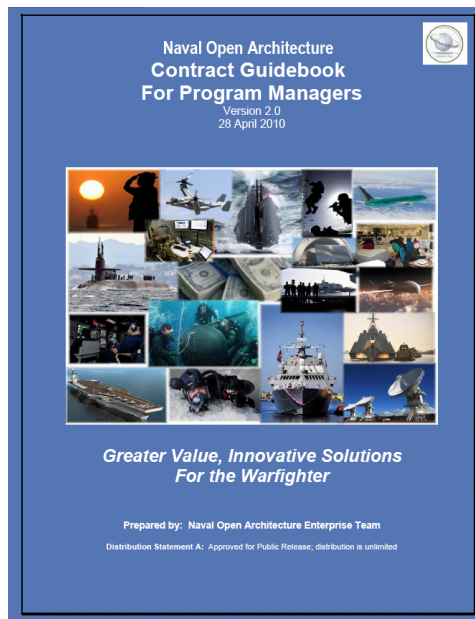
- Several OA efforts in the Navy that are launching points for Open Product Lines and OA MCS
 - PEO IWS: Combat Systems Objective Architecture
 - PEO SUBS: SWFTS Objective Architecture
 - PEO U&W: Future Airborne Capability Environment
 - PEO C4I: Common Afloat Network Enterprise Services
 - DASN RDT&E: Naval Enterprise OA
 - Industry Consortia: Open PLC
 - ASW and MPRF COI's: Data Modeling
 - OMG: Real Time Data Distribution Service

Guiding Principles

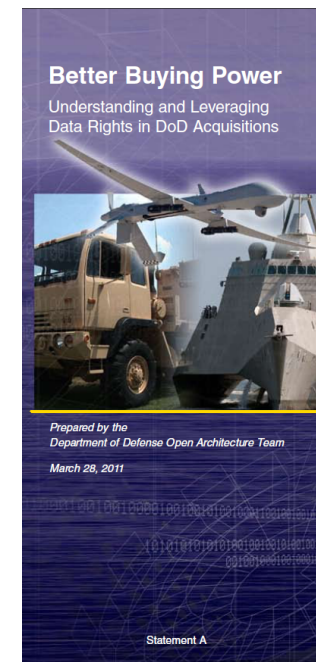
- Reusable, multi-platform, Product Line Modules
- Alignment of MCS Boundaries with physical ship zones
 - Zonal Survivability
 - Improved Construction Performance
- Partition functionality among local, zonal and shipwide controls
 - Ship Construction Testing and System Checkout
- Control Environment Abstraction for configuration independence
- Network Connectivity off-board to enable distance support, status reporting, and eventually MFOP
- Use a hardware business model that uses the commercial market
 - Hardware/Software Independence
 - Technology Insertion production and sustainment model

Evolving Standards to Prevent/Escape Vendor Lock

- Naval Enterprise Architecture Description Document
- Open PLC standard - IEC 61131-3
- Distributed Control and Automation standard IEC 61499
- OMG Real Time Data Distribution Service (DDS) standard
- Understand and use Government Rights to Data



<https://acc.dau.mil/oa>



Next Steps

- Create a MCS Communication Standard and Data Message Content
 - Update MIL STD 1399
- Establish a MCS COI
 - Develop a MCS Data Model
- Write a MCS ADD
 - Evolution into an Naval Enterprise ADD
 - Build off PEOs IWS and Subs ADDs
- Contribute to the Cross-SYSCOM IA Defense-in-Depth Architecture
 - Distance Support reduces support cost; connectivity is needed
- Reusing products from Navy programs
 - Commonality Shelf Products
 - Common Display System/Common Processing System



Backup

Combat Systems OA + Product Lines

Carrier / Amphib Integration

SSDS Update



DDG1000 Integration



New ship class Integration

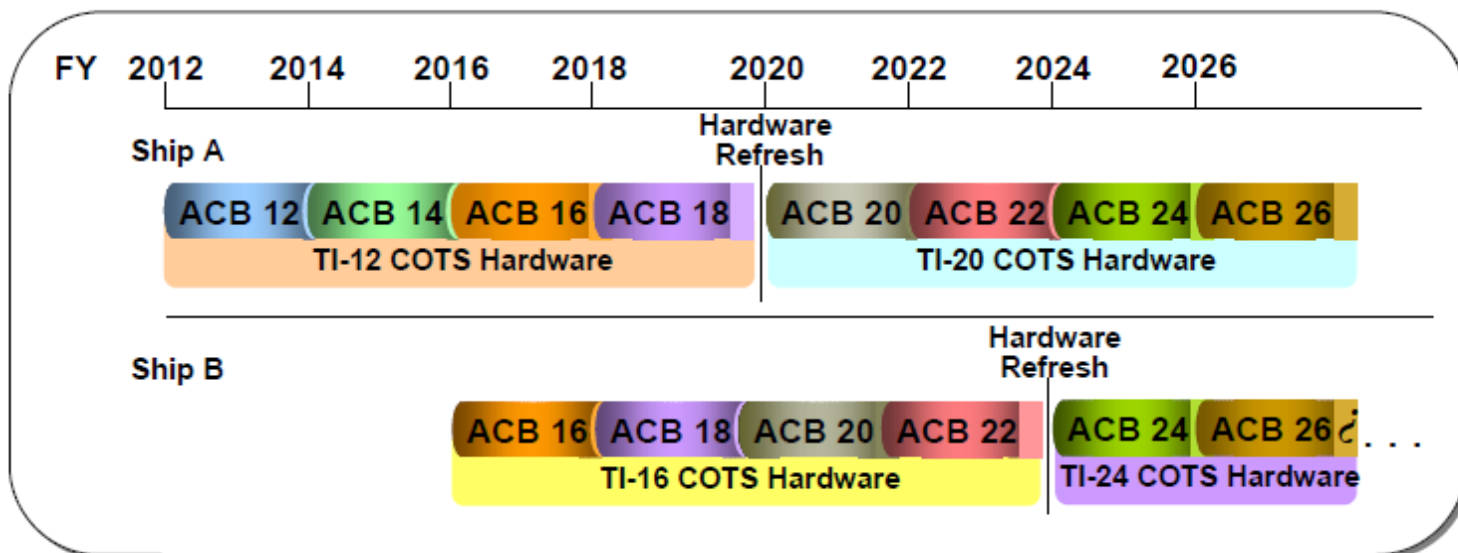
Shared
Components

Aegis Integration



Shared
Components
for Future
Applications
and
Available for
Backfit

Combat Systems Update Cycles



ACB / TI Notional Model

- Requires transition to COTS computing via initial TI
- Each ACB builds on prior ACBs while adding new capabilities
- Transitioned ships receive new ACB every 2 years
- Every ship receives every other TI

Crawl, Walk, Run - Reducing Variation

- Capture the value of recent commonality studies
 - VME
 - PLC
 - Network
 - Protocols
 - Workstation
 - Topology
 - Functionality
 - Methodology
- Target the Cost Drivers
 - System Design and Test
 - Acquisition and Installation
 - ILS
 - Corrective Maintenance and Obsolescence